Hazard Assessment of Utah Courthouses

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Prepared by the Utah Division of Homeland Security- Division of Emergency Services

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INTRODUCTION

This report provides a hazard assessment of risks posed to select Utah Courthouses by natural and technological hazards. Specific hazards addressed in this report include geologic hazard risks such as seismic and landslide activity, flooding, dam inundation, and wildfire. The scope and purpose of this report is to define and identify hazards that can potentially affect the courthouses assessed in this project. This is not an emergency response or management plan, however, this report can be used to identify weaknesses and inform the emergency mitigation and response planning process . The data used for the hazard analyses were gathered from a variety of State Agencies, and special care was taken to ensure that the data used was the most current and accurate information available.

HAZARD DESCRIPTIONS

The information pertaining to each hazard are summaries of hazard description written by experts from various Utah agencies and compiled by the Utah Division of Homeland Security in the Utah Natural Hazards Handbook (2009). These descriptions provide an overview of the hazard as well as a broad description of the where each hazard occurs or could is most likely to occur.

SEISMIC HAZARDS

Most earthquakes occur on faults that form the boundaries of the Earth's tectonic plates. Utah is not on a plate boundary, but many faults in the state can produce large earthquakes. Between Utah's Wasatch Range and California's Sierra Nevada, tectonic forces within the western part of the North American plate combine with the high heat flow from the underlying mantle to literally stretch the crust in an east-west direction at the rate of about one-half inch per year. In response to the stretching, the rigid crust breaks and shifts along faults, and the fault movement produces earthquakes.

Utah straddles the boundary between the extending Basin and Range Province to the west and the relatively more stable Rocky Mountains and the Colorado Plateau to the east. This boundary coincides with an area of earthquake activity called the Intermountain Seismic Belt (ISB). Utah's longest and most active fault, the Wasatch fault, lies within the ISB, a zone of earthquake activity that runs from Canada south through western Montana, eastern Idaho, western Wyoming, along Utah's Wasatch Front into central and southern Utah terminating in north-western Arizona and south-eastern Nevada. Unfortunately, the heavily populated Wasatch Front (Ogden-Salt Lake-Provo urban corridor) and the rapidly growing St. George and Cedar City areas are also within the ISB, putting most of Utah's residents at risk.

An earthquake is the abrupt, rapid shaking of the Earth caused by sudden breakage of rocks when they can no longer withstand stresses that build up within and beneath the Earth's crust. The rocks break along zones of weakness, called faults. Seismic waves are then transmitted outward, producing ground shaking. The principal geologic hazards associated with moderate- to large-magnitude earthquakes include ground shaking, surface fault rupture and tectonic subsidence, soil liquefaction and related ground failure, landslides, and various types of flooding. The distribution and severity of earthquake hazards varies across the state of Utah and depends on earthquake probability (based on the likely size and frequency of earthquakes in an area) and local geologic conditions such as topography, types of soil and rock, and depth to ground water.

Earthquakes can occur anywhere in Utah. Hundreds of earthquakes are recorded each year statewide with most being to small to be felt. Low to moderate earthquakes, those equal to or greater that M5.0, occur once every 10 years along the Wasatch Front and once every 5 years statewide. Moderate earthquakes, those equal to or greater that M6.0, occur once every 50 years along the Wasatch Front and once every 30 years statewide. Large earthquake, those equal to or greater that M7.0 along the Wasatch Front, occur about every 300 to 400 years.

Eastern Utah which lies in the Middle Rocky Mountain and Colorado Plateau Province is a relatively more stable area than the Basin and Ranger Province. Older, shorter faults produce smaller, less-frequent earthquakes. Shallow basins and thinner soil veneers reduce the potential for amplified ground shaking. Liquefaction potential is usually found along streams and adjacent to lakes and reservoirs.

In contract, western Utah lies in the less stable Basin and Range Province. The faults in the province are younger, longer faults capable of producing significantly larger earthquakes than in eastern Utah. Deeper sediment basins are common in the province which could contribute to amplified ground shaking and extensive shallow ground water areas have the potential to liquefy during sustained ground shaking.

The earthquake hazard along the Wasatch Front is critical because more than 80 percent of Utah's population is concentrated here, as are most of the state's utility lines, critical facilities, industries, and major dams. Minimum losses predicted for a major earthquake (magnitude 7.0) in the Salt Lake City area include over $40 billion in damage to buildings alone, 9000 severe injuries and fatalities, and as many as 150,000 displaced households.

There are a variety of hazards created by seismic activity. Strong ground shaking is the greatest hazard during an earthquake because it affects large areas and induces many of the other hazards associated with earthquakes. The intensity of ground shaking in a particular area will depend on the earthquake's location and magnitude, and the local geologic conditions. The shaking generally lasts only a few seconds, and typically lasts 10 to 30 seconds in a moderate to large event. Aftershocks can occur intermittently for weeks or months after the main earthquake. Ground shaking is caused by the passage of seismic waves generated by the earthquake. The waves move the surface laterally and vertically. The lateral motion caused by earthquake waves is responsible for the most damage to buildings, because many older buildings were designed chiefly to withstand vertical loads and not lateral loads. Shaking damages buildings and other structures, either by partial failure or total collapse, and their contents (called non-structural damage) and is a leading cause of death and injury during an earthquake.

During a large earthquake, the fault movement (rupture) at depth may propagate upward along the fault plane and cause rupture of the ground surface. Surface faulting commonly does not occur along a single, distinct plane but may occur over a zone hundreds of feet wide called the zone of deformation (figure 5). The zone of deformation occurs chiefly on the downthrown side of the main fault trace and features include cracking, local tilting, and grabens (down-dropped blocks between faults). These ground displacements may cause damage to buildings and other structures in this zone.

Another hazard that may accompany surface faulting is regional tectonic subsidence accompanying down-dropping and tilting of the valley floor. The amount of regional tectonic subsidence generally depends on the amount of surface fault displacement. The greatest amount will be at the fault and will gradually diminish out into the valley. Tectonic subsidence can cause flooding by tilting lakebeds or dropping the ground surface below the water table in areas of shallow ground water. Tilting can also alter stream courses and lessen or reverse gradients in sewer lines, canals, or other gravity-dependent systems. Along the Wasatch Front, the hazard is significant because Great Salt Lake and Utah Lake may shift eastward and flood shoreline areas in Utah, Salt Lake, Davis, Weber, and Box Elder Counties.

Soil liquefaction during seismic events produces numerous hazard to people and buildings. Soil liquefaction can occur when water-saturated, cohesionless, sandy soils are subjected to ground shaking. The soils “liquefy” or become like quicksand, lose bearing capacity and shear strength, and readily flow on the gentlest of slopes. Liquefaction can cause damage in several ways. On sloping ground, liquefaction can produce various types of mass movement, including lateral spreading and flows. Lateral spreading can take place on gentle slopes of 0.5 to 5 percent. Soil on top of the liquefied zone may move downhill, pulling apart buildings, roads, pipelines, and other buried utilities. On slopes exceeding 5 percent, liquefaction-induced flows can move distances of miles at speeds up to tens of miles per hour.

On flat ground where slopes are less than 0.5 percent, the loss of bearing capacity and shear strength can cause buildings to settle or tip, while lightweight, buoyant structures such as buried storage tanks or empty swimming pools may “float” upward. Also, liquefaction at depth can cause ground cracking and differential settlement at the ground surface.

Foundation materials beneath earthfill dams may liquefy and fail. In low-lying areas, buildings may become flooded with ground water, and gravity-fed systems such as sewer lines may back up because of the change in slope. Liquefaction may occur repeatedly in the same area, both from large aftershocks following the main shock or from subsequent, unrelated earthquakes.

Landslides and rock falls can also produce significant hazards during seismic events. In mountain or canyon areas, landslides and rock falls can be triggered by ground shaking. Landslides and rock falls may be distributed over a wide area in earthquakes larger than magnitude 6.0, but are typically within only a few miles of the earthquake source in smaller earthquakes (magnitude 4.0-5.0).

Rock falls are common during earthquakes and cause damage due to impact. Rock falls may occur as much as 175 miles in any direction from the epicenter of a magnitude 7.5 earthquake, or as much as 50 miles away from the epicenter of a magnitude 6.0 earthquake. During a major earthquake along the Wasatch Front, several thousand rock falls and related shallow slides in rock and loose hillside colluvium could occur near the mountain front and in the canyons.

Along the Wasatch Front, deeper-seated landslides are likely to occur on steep slopes and topographic benches in wet, unconsolidated sediments. Landslides generally do not occur as far away from an earthquake epicenter as rock falls. During a magnitude 6.0 earthquake, landslides typically occur within 25 miles of the earthquake source.

For this analysis, a description for seismic hazard and risk was calculated. Seismic hazard is summarized into three categories: high, moderate, and low. After consulting with University of Utah Seismograph Stations, this hazard rating was developed using a hazard rating was developed using Peak Ground Acceleration (PGA) values. Applying the same relative gradations used by the USGS, the three categories of hazard were defined. A high hazard risk includes PGA values greater than 32%. Moderate hazard ratings include PGA values between 16% and 32 %. Low hazard ratings were assigned to areas with less than 16% PGA. All of these values correspond to a PGA with a 2% probability of being exceeded in 50 years.

Hazard risk was calculated using Modified Mercalli Index (MMI) values for the locations of each courthouse. According to the University of Utah Seismograph Stations, MMI values are a subjective numerical index describing the severity of ground shaking in an earthquake in terms of the effect on objects and humans. A table of MMI values and their corresponding descriptions of potential damage is provided in Appendix A.

LANDSLIDES

Landslides are one of the most commonly occurring natural hazards in Utah. The state has a long history of damaging landslides in both rural and urban areas. Landslides have caused loss of lives, damaged or destroyed buildings and transportation routes, and dammed rivers causing destructive flooding.

Landslides are most common in areas having moderate to steep slopes, weak slope materials, and relatively wet climates. In these landslide-prone areas, most landslides are associated with precipitation events – either periods of sustained aboveaverage precipitation, individual intense rainstorms, or snowmelt events. Erosion, removal of vegetation by wildfires, and earthquake ground shaking increase the likelihood of landslides. Human activities such as grading of slopes and increasing soil moisture through landscape irrigation can also trigger landslides.

The landslide distribution in Utah is dependent on geology, topography, and climate. Landslides are most numerous in the Middle Rocky Mountains physiographic province and in the High Plateaus section of the Colorado Plateau physiographic province where weak rock types, steep slopes, and relatively abundant precipitation contribute to landsliding. Landslides are much less common in the arid Basin and Range and Colorado Plateau provinces.

The Middle Rocky Mountains province includes the steep mountainous terrain of the Wasatch Range and Uinta Mountains. Landslides in the High Plateaus section of the Colorado Plateau physiographic province are concentrated along steep plateau and mountain slopes. Rock falls and topples are numerous in mountainous and plateau areas throughout the state. Weak rock types susceptible to landsliding also influence the landslide distribution in Utah. Many geologic formations that contain weak landslide-prone rocks occur within the High Plateaus section of the Colorado Plateau physiographic province, and some of the largest landslides in the state are in this province.

Urban valleys are prone to landslides, particularly where development has taken place on existing landslides or where grading has changed the slope gradient and reduced slope stability. Numerous landslides along the Wasatch Front occur in steep slopes composed of sediments deposited in Lake Bonneville (the prehistoric, freshwater predecessor to Great Salt Lake). Buildings at the top and bottom of these slopes have been damaged by landslides. Excessive landscape irrigation has contributed to landsliding in some areas. Buildings on alluvial fans below steep mountain drainages are at risk of damage from debris flows.

The Utah Geological Survey provided the data used to conduct the risk analysis of each courthouse. Their landslide susceptibility categories were calculated using slop angle measurements and include high, moderate, low, and very low classifications. Specific descriptions for each category are provided in the individual court hazard assessment section.

DAM FAILURE

Dam failures can pose a great hazard to property and life. More than 200 of the dams in Utah are considered high hazard, meaning that they have the potential to kill someone if there was an uncontrolled release. Another 200 dams have a moderate hazard rating, or the potential to cause significant property damage. Dams are usually man made and are not inherently natural hazards but dam failures can occur by natural hazard loading events. Causes of dam failures are: breach from flooding or overtopping; ground shaking from earthquakes; settlement from liquefaction; slope failure and slumping;

internal erosion from piping; failure of foundations and abutments; outlet leaks or failures; and even vegetation and rodents can cause internal problems in the dam embankment**.**

There are basically two types of dam failures – “rainy day” and “sunny day” failures. Rainy-day failures occur because floodwaters overstress the dam, spillway, and outlet capacities. The water eventually flows over the top of the dam and erodes the structure from the top down, slowly at first, but eventually catastrophically. The breach flows of the dam, which can be tremendous, are added to the floodwaters from the rainstorm to produce a flood of large proportion and destructive power.

The sunny-day failure occurs from seepage and erosion inside the dam that removes fine material, creating a large void that can cause the dam to collapse or overtop and wash away. Earthquakes can cause cracks in the dam or liquefaction (temporary loss of strength) of the foundation. This can cause the dam to start piping, slump, settle, experience a slope failure similar to a landslide that deforms the dam enough to fail internally or overtop and wash away. Vegetation and rodents in dam embankments or in the spillway can cause problems. Root systems and burrowing rodents can leave holes and tunnels, which could lead to failures. Sunny-day failures can be the most dangerous because they can happen quickly and surprise the owner or downstream inhabitants.

Dams can also “fail,” or not perform as they were designed, but not have a catastrophic release of water. They are usually drained and fixed after this kind of failure. Because dam science (geotechnical engineering, hydrology, hydraulics, geology, statistics, structures, and meteorology) is not an exact science, dams are designed with a “Factor of Safety,” which is at least 50 percent stronger than they really have to be, to compensate for errors in science calculations, judgment, construction, and the unquantifiable properties of our world.

Effects of dam failures can include: flooding, silting, loss of life, loss of property, loss of the dam, and loss of water resource (water and storage). After a dam breaks there is a huge flood of water. The water level in the channel below a dam breach can rise so quickly that it appears like a wall of water and debris flushing downstream. The flood proceeds downstream fairly rapidly, flooding lowlands, backing up behind bridges, and gradually decreasing in size and speed. As the floodwaters recede there is a prolonged period of high flows as the water stored in flooded lowlands drains.

The State Dam Safety Section has developed a hazard rating system for all non-federal dams in Utah. Downstream uses, the size, height, volume, and incremental risk/damage assessments or dams are all variables used to assign dam hazard ratings in Dam Safety’s classification system. Using the hazard ratings systems developed by the Dam Safety Section, dams are placed into one of three classifications high, moderate, and low. Dams receiving a low rating would have insignificant property loss do to dam failure. Moderate hazard dams would cause significant property loss in the event of a breach. High hazard dams would cause a possible loss of life in the event of a rupture. The frequency of dam inspection is designated based on hazard rating with the Division of Water Rights inspecting high-hazard dams annually, moderate hazard dams biannually, and low-hazard dams every five years. Currently, there are a total of 906 dams in Utah, and of those 906 dams, 227 have received a high hazard rating by Dam Safety.

The rankings below were compiled as part of a hazard evaluation designed by the Federal Energy Regulatory Commission FERC. The dam rankings are assigned by a priority score with takes into account numerous variables some of which include: public access, population at risk, breach flow, inundation depth, and dam type. The listed ranking shown below only includes those 50 dams with the highest priority score. This figure lists only the top 50 as priority scores drop dramatically there after.

Top 50 Dams with Highest Priority Scores

1. Mountain Dell
2. Little Dell
3. Utah Power & Light Cutler
4. Quail Creek
5. Salt Lake County Sugarhouse
6. Logan First Dam
7. Quail Creek South Dam
8. Utah Power & Light Electric Lake
9. Porcupine
10. Red Butte Dam
11. Sevier Bridge
12. Panquitch Lake
13. Sand Hollow North Dam
14. Sand Hollow West Dam
15. North Utah County Tibble Fork
16. Adams
17. Twin Lakes Salt Lake County
18. Settlement Canyon
19. Utah County Thistle Creek Debris
20. DMAD
21. Gunnison Bend
22. Big Sand Wash
23. Kens Lake
24. Piute
25. Smith and Morehouse
26. Millsite
27. Sand H Debris
28. Hobbs
29. Lake Mary-Phoebe
30. Salt Lake County Big Cottonwood Spencer's
31. Haight Creek Lower
32. Provo City-Rock Canyon DB
33. Provo City- Slate Canyon BD No. 3
34. Holmes
35. Huntington
36. Kennecott Mine Bingham Creek
37. Three Creeks- Beaver
38. Davis County-Barton Creek DB
39. Gunlock
40. Lloyds Lake-Monticello
41. Forsyth
42. Blanding City No. 4
43. Utah County-American Fork Debris
44. Kaysville
45. Mill Meadow
46. Grantsville
47. Ash Creek
48. Gunnison
49. Davis County-Stone Creek DB
50. Tony Grove Lake Dam

The Bureau of Reclamation and the Utah Division of Water Rights provided the data used to conduct the dam inundation analyses. For the scope of this project, we provided information as to whether each courthouse was located within a possible dam inundation zone and a description of the risk.

WILDFIRE

Wildfire starts occur naturally in Utah —predominately through lightning— though some fires are initiated through human activity. Conditions affecting wildfire behavior in Utah's interface areas can include natural conditions such as vegetation or fuels, topography, and weather; or man-made conditions including homes or subdivisions, their design, and infrastructure.

The wildland/urban interface (WUI), or locations where wildland and residential areas meet, presents a serious fire threat to life and property. The large population shift from urban to rural areas has placed many more people in wildland areas and increased potential fire starts. WUI areas in Utah are capable of having large disastrous wildfires that may destroy numerous buildings, cause injuries, and loss of lives. Other adverse effects of wildfires are due to removal of vegetation, which can cause soil erosion and reduction of the soils ability to adsorb water, thus increasing risk of excess water runoff and slope movements. The elimination of vegetation also depletes feed and cover for wildlife.

WUI homes are generally found in areas with established fire intervals associated with the native vegetation, which present a two-way problem. Fires may burn from the wildlands into private homes and subdivisions, or fires may start in a home and spread into the adjacent wildland fuels. Firefighting in the interface is difficult because prevention methods and suppression tactics and strategies normally used may not be possible. Interface fires are dangerous to firefighters due to the complexity of fuels (homes) found there.

The risks from wildfires can be reduced in numerous ways. Some mitigation methods include: selecting the most safe site for construction; vegetation management, installing fire-resistant roofing, using fire-resistant building materials, providing adequate access to buildings, insuring adequate water supply and delivery systems, and community actions.

Data used to conduct the wildfire hazard analysis was provide by the BLM and the US Department of the Interior. These analyses assess wildland fire hazards based on a combination of accumulated values including landcover, fire hazard potential, and vegetation. DHS simplified the BLM ratings, categorizing them into one of four ratings low, moderate, high, and extreme. Extreme wildfire risk indicates that the fire has a high resistance to control, exhibits extreme intensity levels resulting in almost complete combustion of vegetation and possible damage to soils and seed sources depending on slope, rates of spread, wind speed and fuel loading. A high wildfire risk rating indicates that fires in this area will have a moderate to high resistance to control and will result in high to moderate damage to resources depending on slope, rates of spread, wind speed, and fuel loading. Moderate wildfire hazard ratings signify that wildfires in this area are expected to have moderate to low resistance to control and that fire intensity levels would generally be low with moderate damage to resource values depending on slope, rates of spread, wind speed, fuel loading. Low wildfire risk suggests that a wildfires in this area will have low to moderate resistance to control, and that the fire intensity levels would generally be low with little threat to human values and potentially beneficial to resource values depending on slope, rates of spread, wind speed, and fuel loading.

FLOOD

Floods have been, and continue to be, the most destructive natural disaster in terms of economic loss to the citizens of Utah. Floods can happen anywhere, at anytime. Major floods in Utah are almost always the result of rapidly melting snow in late spring and early summer and accompanied by thunderstorms.

Flooding in Utah originates from four distinct processes: flash flooding, long-term rainfall events, spring snowmelt river flooding, and dam break flooding. Long-term rainfall flood events occur mainly in the southern half of the state, and most times, in the Paria, San Rafael, Price, Virgin and Santa Clara River Basins. These rain events occur mostly in the fall or wintertime months and are produced by large synoptic weather systems originating out of the south, southwest, or west. The flow generally is a strong and persistent area of low pressure off the Pacific tapping into a plume of subtropical moisture. This system produces rainfall for an extended period. Some melting of snow may occur as a result of the rainfall.

Spring snowmelt runoff flooding is caused by the rapid spring snowmelt of mountain snow packs. Most times, intense spring rainfall assists the flood scenario, causing additional rapid river rises. Flooding from these events mostly affect property owners and municipalities. These events can last for weeks during the spring and result in loss of life and extensive damage. Flooding may occur in valley areas due to the ponding of mountain runoff accumulates after many days of heavy runoff. Additionally, more damage is occurring over the years as a result of increased development near the riverbanks of mountain streams.

Floods due to dam breaks are almost always catastrophic, short-lived, and very dangerous. While these events may occur infrequently, it is important that the Emergency Community be well versed on the nature of a dam break. From the proper call list to execute depending on the amount of damage to the dam, to the proper procedures to take is the dam is indeed ready to fail. The National Weather Service currently maintains the most widespread dissemination network to warn for these events. Field offices throughout the country are staffed and alert 24/7 to the possibility of a dam break

Utah, in recent years has seen a new kind of flood risk emerge; that of canal failures and flooding and debris flows related to watersheds damaged by wildfire. This type of flooding is distinctly different from the floods normally dealt with. As Utah continues the move from rural predominantly farmland to urban areas large amounts of land traditionally used for framing is being converted to residential development. This development, occurring in a patchwork fashion, is leaving irrigation canals in place to transport water to undeveloped farms. This is placing residential development near and often below un-engineered irrigation canals. Irrigation canals have a history of breaching, yet development pressure has now put homes at the base of many of these canals.

Post fire-related flooding results from enhanced runoff from fire-damaged watershed. As fires burn they destroy vegetation and often leave soils in a hydrophobic state, this alters the hydrology of the watershed, producing greater peak flows. It takes the human built environment to turn a natural event into a natural disaster. Development on the foothill all along the Wasatch Front is occurring, at rapid rates. Foothill property is considered prime real estate and is more often than not in WUI areas on step slopes.

Flood risk ratings were gathered from NFIP (National Flood Insurance Program) maps. While most courthouses fell within an NFIP Flood Zone, several did not. In these instances, topographic maps from the USGS were analyzed to create a probable risk rating. The flood risk for each courthouse was analyzed and flood zone and flood risk descriptions are provided in the hazard risk summaries.